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REPLACEABLE TREAD TIRE PROTOTYPE DEVELOPMENT FOR C-130 MILITARY AIRCRAFT FLIGHT TESTS

THE B. F. GOODRICH COMPANY
AKRON, OHIO 44318

10 James W. Pond

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This technical report has been reviewed and is approved for publication.

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FOR THE COMMANDER

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Two assemblies, 51.5x20-20, featuring standard aircraft tire rubber coat, completed 310 dynamic test cycles. Two assemblies, featuring an alternate rubber carcass coat, failed prematurely.

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FOREWORD

This report was prepared by James W. Pond, of the BFGoodrich Tire Division, A Division of The BFGoodrich Company, under USAF Contract F33615-76-C-3060. The work was conducted under the direction of the Vehicle Equipment Division, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, P.M. Wagner (AFFDL/FEM), Project Engineer. This report covers work performed under Contract F33615-76-C-3060 between May 1976 and June 1977. This report was submitted by the author May 1977 for publication as a technical report.

The author wishes to acknowledge the contribution of J.K. Willey (BFGoodrich) for manufacture of tire assemblies, A.R. Middlecoop (BFGoodrich) for assistance in dynamometer testing, and P.C. James (BFGoodrich) and J.T. Warchol (BFGoodrich) for assistance in this development effort.

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SECTION I
INTRODUCTION

1.1 Major logistics costs and considerable aircraft out-of-service time are caused by the wear of tires on Air Force aircraft. Approximately 90% of the flight line tire removals from military aircraft are due to the condition of the tire treads. The remaining 10% are caused by a variety of reasons including sidewall blisters, damaged carcasses and "contamination" by a damaging fluid spillage on the tire. In case of tread defects, approximately 10% of the removals are caused by tread stripping, chunking and other miscellaneous causes. However, by far, the greatest number of tire removals are for tread wear and tread cutting. These two causes constitute approximately 80% of the total number of tire removals.

1.2 In order to reduce the expense of tire wear to the Air Force, the C-130 Replaceable Tread Tire Development Program was undertaken. This tire concept will allow worn or cut treads to be removed and replaced in the field. By replacing only that part of the tire that wears out, the weight to be transported to the field is reduced by 75%. In addition, maintenance manhours associated with tire changes are reduced 80%. The overall objective of the program is to develop, qualify, service test and evaluate a preproduction prototype Replaceable Tread Tire for the C-130 aircraft.

SECTION II
GENERAL BACKGROUND

2.1 Advances in Replaceable Tread Tire (RTT) performance during Phase II of Contract F33615-72-C-1349 and the redirection of Contract F33615-72-C-1361 were significant. Each design/test iteration during these development efforts have resulted in the achievement of an appreciably higher level of tire improvement. The latest design/test iteration has shown that the C-130 RTT has approached the number of dynamic test cycles needed for tire qualification prior to flight tests; however, additional design effort and laboratory design effort are required to achieve qualification of a flightworthy RTT assembly for the C-130 aircraft.

2.2 The next logical step in the overall C-130 RTT program is to develop, qualify and flight evaluate developmental prototype tire assemblies. This next step was designated Phase IV, Developmental Prototype RTT Test and Evaluation, since it is a follow-up on work conducted under Phase III of Contract F33615-72-C-1349.

SECTION III
TASKS

3.1 Developmental investigation under Contract F33615-76-C-3060 was divided into three phases.

3.1.1 Phase IVA - Carcass and tread band improvements in performance and manufacturing.

3.1.2 Phase IVB - Provide a limited quantity of optimum assemblies from Phase IVA to AFFDL for evaluation of mechanical properties at AFFDL/WPAFB.

3.1.3 Provide AFFDL RTT assemblies for flight tests.

SECTION IV
TECHNICAL REQUIREMENTS

4.1 Re-design and rework existing carcass mold to alter the deep sidewall convolute to a single shallow convolute and incorporate a feature in the shoulder area to aid in centering the tread band on the carcass. These mold alterations were done.

4.1.1 Manufacture assemblies, using the revised carcass mold to evaluate a standard aircraft carcass rubber coat compound. Revised tread band constructions were to be used in an attempt to improve tread band performance. Four assemblies of each configuration were required.

4.1.2 Conduct static laboratory tests as outlined by AF Drawing 65-D-1542H on each test configuration. This was done on one test only as authorized by AFFDL letter dated 1 November 1976 (FEM/P.M. Wagner/52663).

4.1.3 Conduct dynamometer tests of two assemblies each configuration to AF Drawing 65-D-1542H.

4.1.4 Supply one assembly each configuration to AFFDL for their evaluation.

4.2 By mutual agreement, AFFDL and the contractor select the optimum RTT assembly, then manufacture and supply to AFFDL four optimum assemblies for static and dynamic laboratory tests.

4.3 By mutual agreement, between AFFDL and the contractor, manufacture and supply AFFDL six RTT assemblies for flight tests.

SECTION V
TEST RESULTS - CONTRACTOR FACILITY

5.1 Static Tests - Measurements were taken and a hydrostatic burst was conducted on the first construction check assembly, Table 1. During the hydrostatic burst, the tread band failed at 800 psi. The specification burst pressure for this tire assembly is 560 psi minimum (160 psi rated pressure times a 3.5 burst factor). A second burst test was conducted on the same carcass, but without a tread band. The carcass failed at 600 psi, which is considered exceptional for this single component. Inflated Profile, Tire Footprint and Load-Deflection Curve are shown in Figures 1, 2 and 3, respectively.

5.2 Dynamic Tests - This phase of contract F33615-76-C-3060 was to evaluate two carcass coat compounds; one being the present standard material used for aircraft tires, the second an alternate high quality material. Also, an alternate tread band construction was to be evaluated.

The alternate tread band construction failed early during the dynamic indoor tests. A return to previously employed tread band constructions was indicated before further tests were justified.

The alternate carcass coat material did not perform well; one carcass failed at 41 TTO cycles, and the second carcass failed at 31 TTO cycles.

Two carcasses using the standard aircraft tire carcass coat material completed the 310 dynamic test cycles as required by Air Force drawing 65-D-1542H. Refer to Table 2.

TABLE 1

STATIC LABORATORY TESTS

51.5x20-20/30PR

EC/RT

LABORATORY TEST			
Specifications - Carcass - Tread Band	B359 B361		
Weight - Carcass - Tread Band	164 Lbs. 89.5 Lbs.	Total 253.5 Lbs.	283.5# Max.
Inflated Section Width - 24 Hr. Growth	19.70"		21.10" Max.
Inflated Section Width - Loaded 46,500@160 PSI	22.23"		
Deflection @ 46,500 Lbs. - 160 PSI	3.75" (28%)		31+3-4%
Inflated Diameter	51.00"		50.6" Min.
Inflated Tread Width - To Radius @ Shoulder	13.60"		17.50" Max.
Inflated Tread Radius - (Calculated)	120.0"		
Hydrostatic Burst - 1st - 2nd	800 PSI (Tread Band) 600 PSI (Carcass-Crown)		560 PSI Min.

Footprint Data:

	Crown	Shoulder
Length	17.1"	21.6"
Area - Cir.	284 Sq.In.	
- Actual	241 Sq.In.	

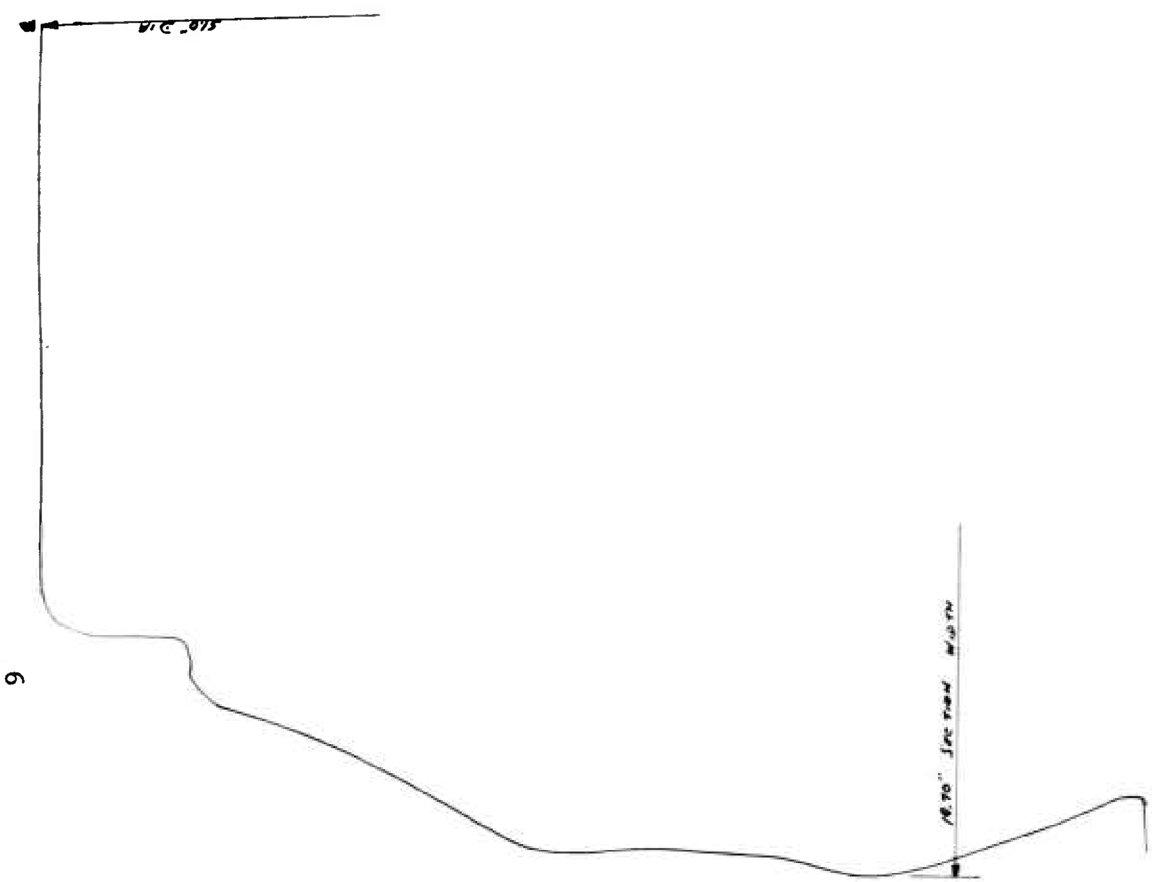


FIGURE 1

ALL FRACTIONAL DIMENSIONS TO BE ± 1/64" & DECIMAL DIMENSIONS ± .005" UNLESS OTHERWISE NOTED

THE B. F. GOODRICH COMPANY
TIRE DESIGN DIVISION

SUBJECT INFLATED TIRE PROFILE
51.5-20-20 30 PR 160 PSI
FROM TEMPLATE

DRAWN BY J.W.P DATE 12-10-76 CHD

MOLD DRG ______ W. T. DRG ______

APPROVED BY ______ R. DRG ______

P-

Figure 1. Inflated Tire Profile

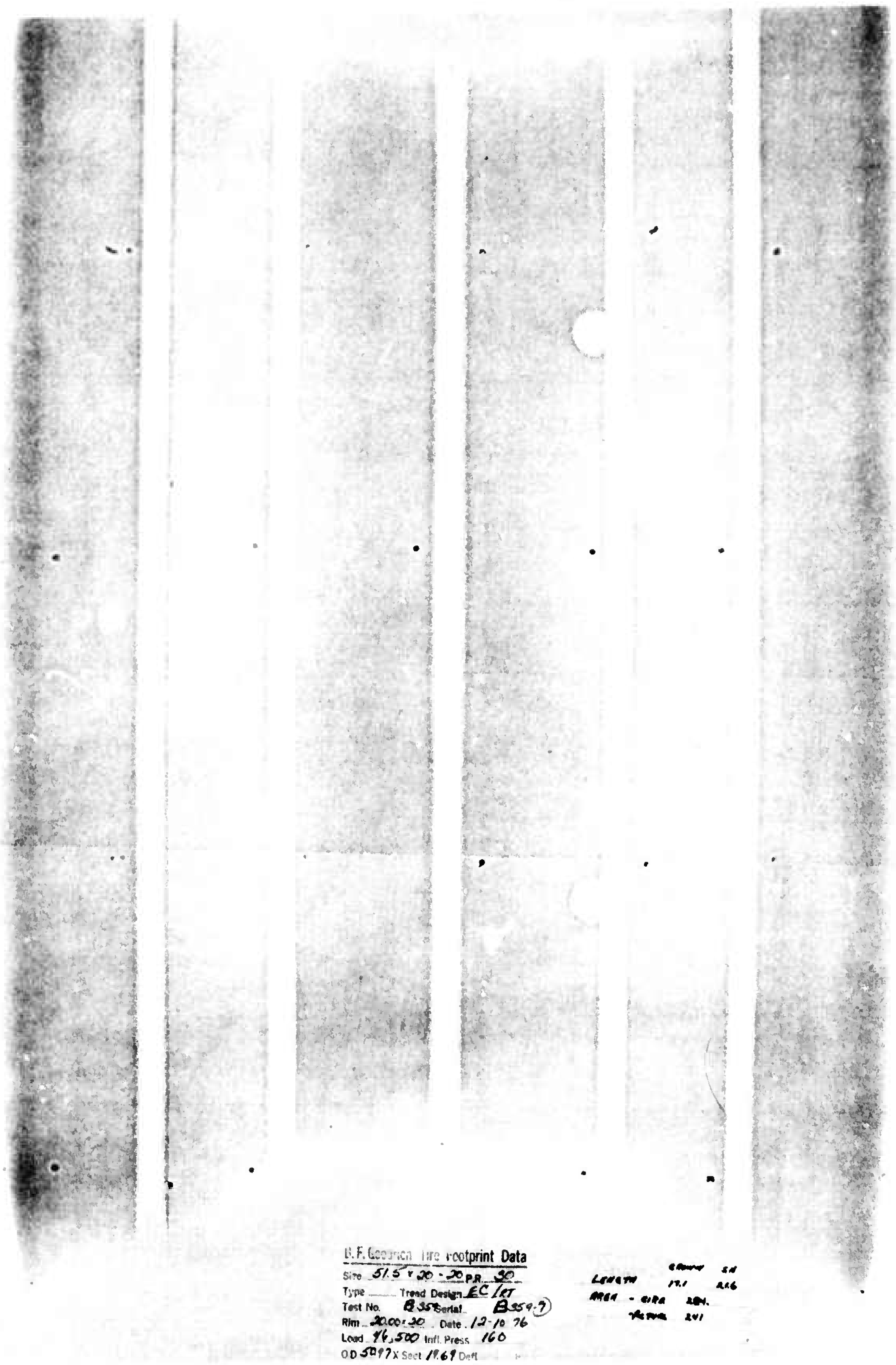
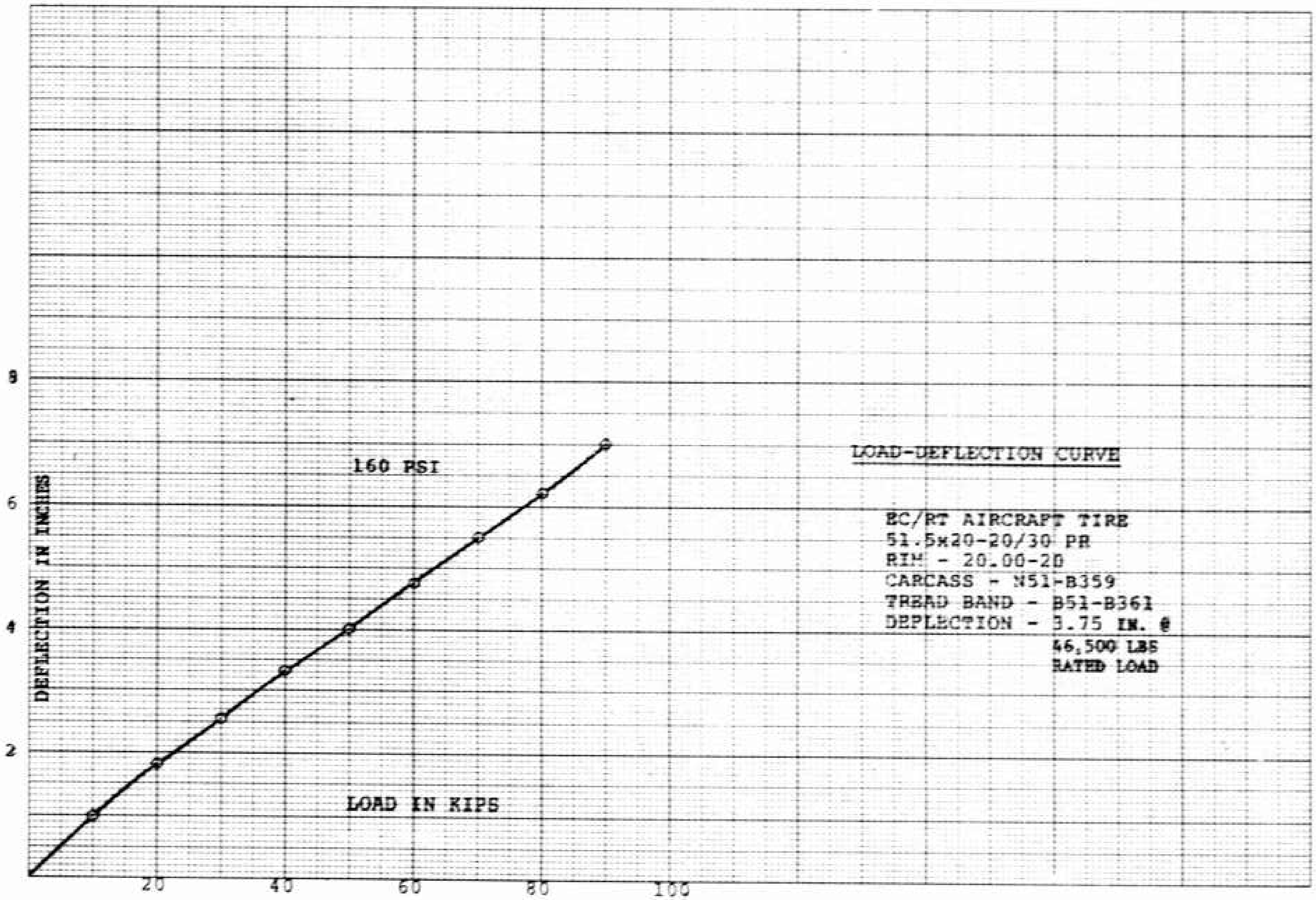


Figure 2. Loaded Tire Footprint



LOAD-DEFLECTION CURVE
BC/RT AIRCRAFT TIRE
51.5x20-20/30 PR
RIM - 20.00-20
CARCASS - N51-B359
TREAD BAND - B51-B361
DEFLECTION - 3.75 IN. @
46,500 LBS
RATED LOAD
160 PSI
DEFLECTION IN INCHES
LOAD IN KIPS
2
4
6
8
20
40
60
80
100

FIGURE 3

Table 2
DYNAMIC LABORATORY TESTS
51.5x20-20/30 PR
EC/RT

PHASE I

	No. Cycles Actual	Required
Experiment #1 - Test No. 1		
Standard Carcass Coat		
(a) Spec No. B-359 #2 Carcass		
Spec No. B-361 Tread Band	"A" - 44	
Failure - tread band		
(b) Spec No. B-359#2 Carcass		
Spec No. B-391#1	"A" - 81	
	"B" - 125	
	"C" - 60	
TOTAL	310	310
Experiment #1 - Test No. 2		
Standard Carcass Coat		
Spec No. B-359#4 Carcass		
Spec No. B-361 Tread Band	6	
Failure - tread band		
Spec No. B-359#4 Carcass		
Spec No. B-391#15 Tread Band	21	
Failure - tread band		
Spec No. B-359#4 Carcass		
Spec No. B-391#6 Tread Band	28	
Failure - tread band		
Spec No. B-359#4 Carcass		
Spec No. B-391#10 Tread Band	57	
Spec No. B-359#4 Carcass		
Spec No. B-391#9 Tread Band	"A" - 13	
	"B" - 125	
	"C" - 60	
TOTAL	310	310
Experiment #2 - Test No. 1		
Alternate Carcass Coat		
Spec No. B-360#2 Carcass		
Spec No. B-391#3 Tread Band	49	310
Failure - carcass separation		
Experiment #2 - Test No. 2		
Spec No. B-360#3 Carcass		
Spec No. B-391#4 Tread Band	31	310
Failure - carcass separation - tread separation		

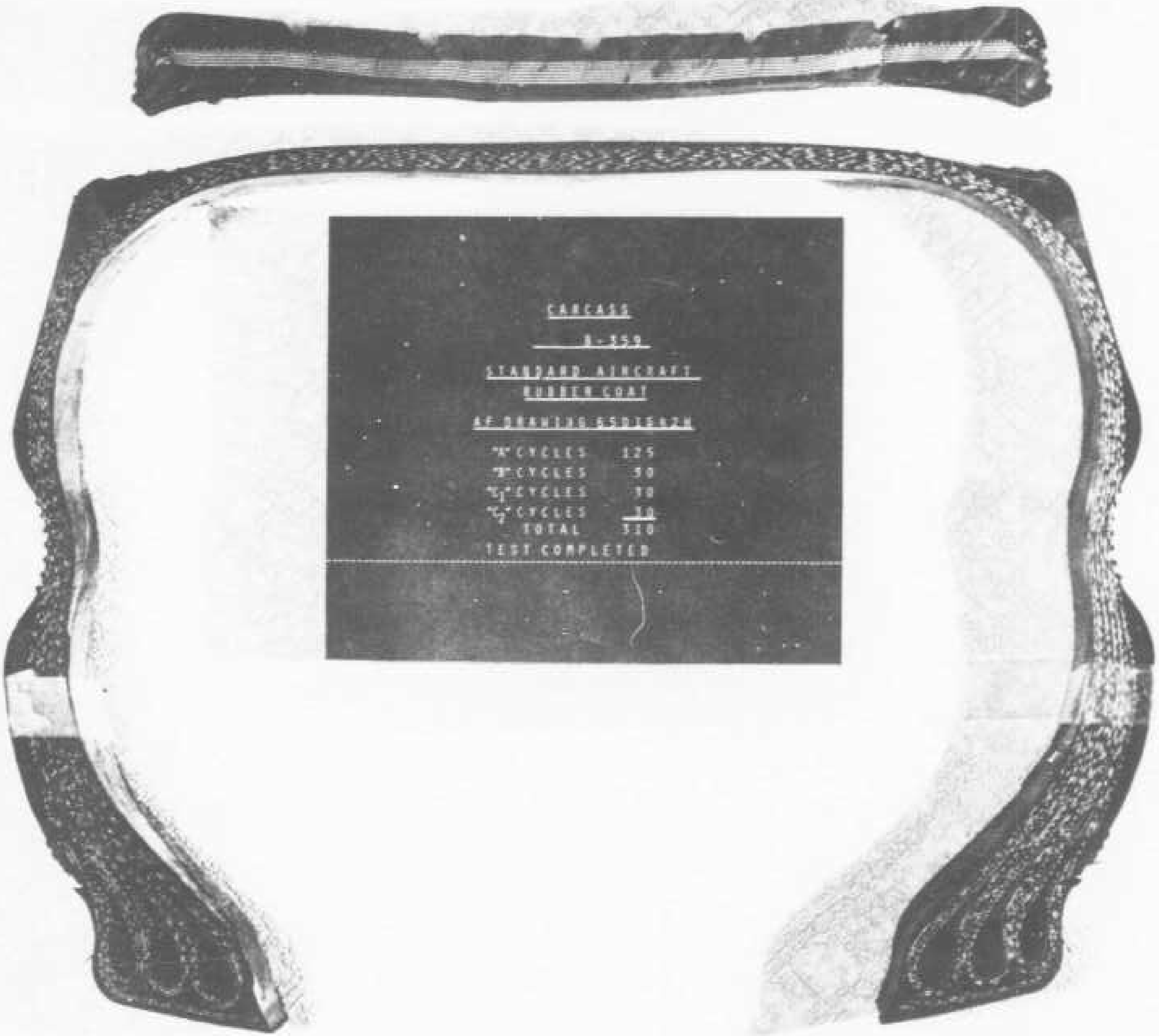

CARCASS
STANDARD AIRCRAFT
RUBBER COAT
"A" CYCLES 125
"B" CYCLES 50
TOTAL
TEST COMPLETED

FIGURE 4

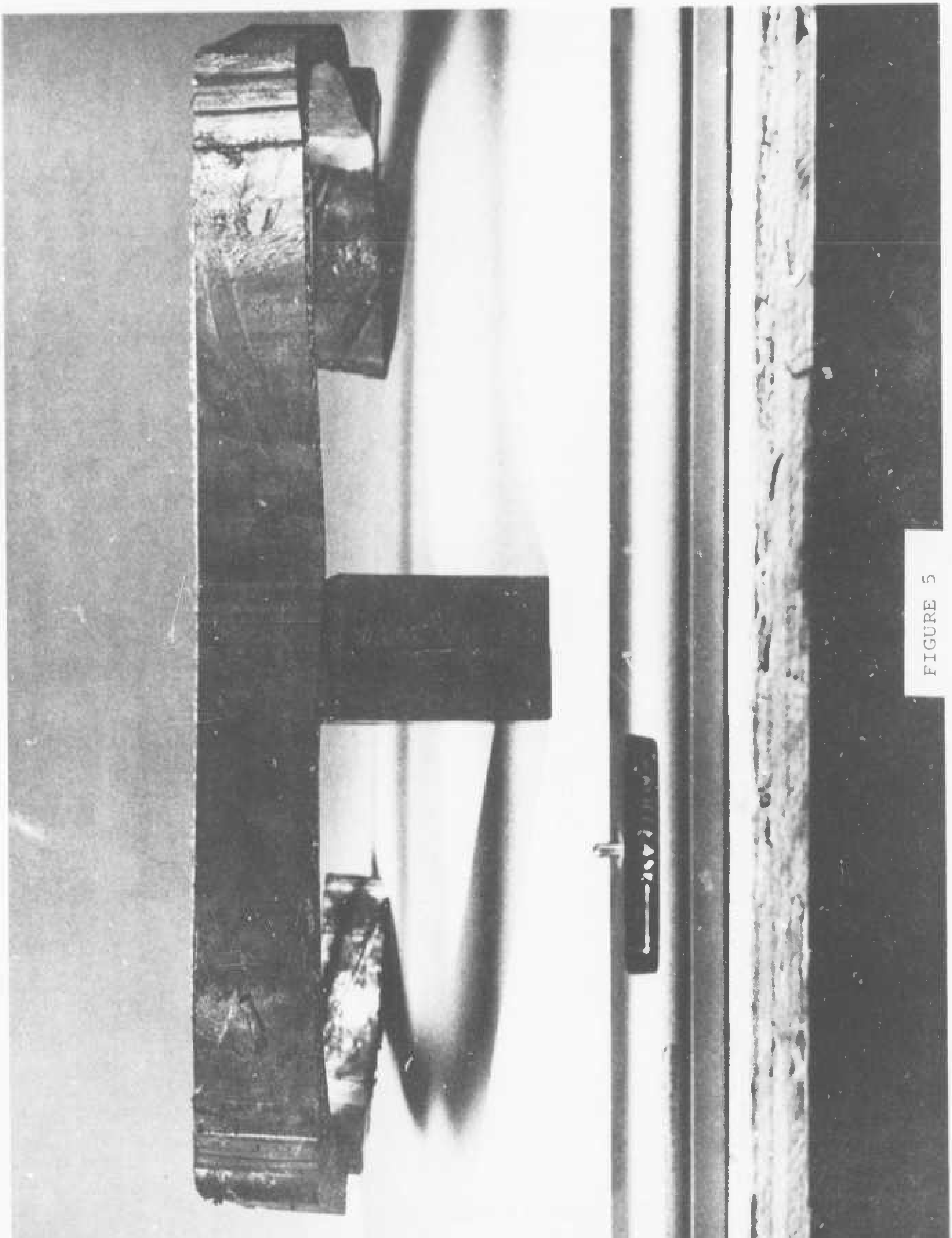


FIGURE 5

FIGURE 6

SECTION VI
OBSERVATIONS AND COMMENTS

6.1 Static Laboratory Tests - Table 1.

6.1.1 All dimensions are within limits specified in the statement of work of Contract F33615-76-C-3060.

6.1.2 Deflection at rated load and inflation is within specified limits.

6.1.3 Hydrostatic burst was 42% above the required minimum.

6.2 Dynamic Tests - Table 2.

6.2.1 Two carcasses, featuring standard carcass rubber coat compounds, completed the 310 test cycles specified in AF Drawing 65-D-1542H without visible or apparent failure. Analysis of cut sections indicated incipient separation in the lower sidewall area but to a lesser degree than previously encountered.

Chafing of the bead, in the rim flange area, was encountered.

6.2.2 Premature failure of tread bands occurred due to separation of tread from cords. A retest of adhesion of tread to cord showed an acceptable level. Actual cause of tread separation could not be determined. New tread bands were fabricated which provided improved performance.

6.2.3 Two carcasses, featuring an alternate rubber coat compound failed prematurely.

6.2.4 In Experiment No. 1, Test No.2, five tread bands were used to complete the dynamometer test. No difficulty was encountered in tread band removal or replacement on the carcass.

6.3 Review - During the development efforts of the Replaceable Tread Aircraft Tire, many problems have been solved, including:

6.3.1 Tread band breakage - solved by a construction change.

6.3.2 Tread band splitting - circumferentially; solved by a construction change.

6.3.3 Rubber chunking and stripping from the underside of the tread band; solved by a construction change.

6.3.4 Chafing at the interface of the tread band and the carcass in the shoulder area; solved by alterations in aspect ratio, tread radius and rubber compound selection.

6.3.5 Blisters (trapped air) in the carcass-shoulder area; solved by construction and technique change.

6.3.6 Trapped air between the curing bladder and the carcass; solved by construction and technique changes.

6.3.7 Bladder pinch-out resulting in a carcass defect; solved by bladder and technique changes.

6.3.8 The changes in equipment, constructions, and technique have resulted in improved performance from 1 to 7 dynamic test cycles to the completed 310 dynamic test cycles specified by Air Force drawing 65-D-1542H.

6.4 Recommendations - while good progress has been made in development of the EC/RT concept, there are certain conditions which require further investigation and improvement.

6.4.1 Exposed cords in the carcass sidewall in the convolute area. Seven experiments have been made, intended to eliminate this condition, without success.

6.4.2 Carcass separation, lower sidewall area.

6.4.3 Chafing of the bead, rim flange area.

6.4.4 Separation of rubber from cord in the shoulder area of the tread band.

6.5 The contractor recommends that this development effort be continued under a new contract to obtain a fully-qualified EC/RT assembly for the C-130 aircraft. Obtain new mold equipment at contractor expense of new design and concept to further improve or eliminate the few remaining problem areas in tire assembly performance and manufacture.

6.6 During the meeting of AFFDL on 20 April 1977, mutual agreement was reached as to constructions and carcass compound to be manufactured by the contractor for Phases II and III of contract F33615-76-C-3060. Such agreement includes (a) standard aircraft carcass coat compound, (b) tread band construction to provide maximum tread radius using existing mold equipment, (c) minimum sidewall rubber thickness.

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